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Original Article

Occurrence of gastrointestinal parasites in dogs from Cuiabá, Mato Grosso

Ocorrência de parasitos gastrointestinais em cães de Cuiabá, Mato Grosso

Cristiane Trevisan Viana de Souza[1]; Ana Paula Dorr[2]; Victória Luiza de Barros Silva[1,2]; Fabiane de Lima Silva[3]; Eveliny Barroso da Silva[3]; Dirceu Guilherme de Souza Ramos[4]; Richard de Campos Pacheco[1,2*]; Valéria Régia Franco Sousa[1,5]

[1]Programa de Pós-graduação em Ciências Veterinárias – PPGVET, Faculdade de Medicina Veterinária – FAVET, Universidade Federal de Mato Grosso – UFMT, Cuiabá, MT, Brasil
[2]Laboratório de Parasitologia Veterinária e Doenças Parasitárias dos Animais Domésticos e Silvestres, Hospital Veterinário – HOVET, Faculdade de Medicina Veterinária – FAVET, Universidade Federal de Mato Grosso – UFMT, Cuiabá, MT, Brasil
[3]Departamento de Estatística, Instituto de Ciências Exatas e da Terra – ICET, Universidade Federal de Mato Grosso – UFMT, Cuiabá, MT, Brasil
[4]Laboratório de Patologia e Parasitologia Veterinária, Unidade Acadêmica de Ciências Agrárias, Universidade Federal de Jataí – UFJ, Jataí, GO, Brasil
[5]Laboratório de Leishmanioses, Hospital Veterinário – HOVET, Faculdade de Medicina Veterinária – FAVET, Universidade Federal de Mato Grosso – UFMT, Cuiabá, MT, Brasil

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Abstract

Gastrointestinal parasitism by helminths and protozoa poses risks to animal and human health owing to clinical changes and transmission of potentially zoonotic agents. Thus, the present study aimed to verify the occurrence of gastrointestinal parasites in dogs from the municipality of Cuiabá, Mato Grosso, Brazil, using coproparasitological tests. From June 2021 to April 2022, faecal samples were collected from domestic dogs at the Veterinary Hospital and Animal Protection Shelters in the Cuiabá municipality. A semi-structured questionnaire was applied to the owners and those responsible for the shelters to analyse the factors associated with gastrointestinal parasitism. A total of 353 faecal samples were collected and subjected to parasitological flotation and sedimentation techniques. Data were analysed using the chi-squared test and exploratory factorial analysis. The occurrence of gastrointestinal parasitism was 22.66% and the parasites found alone or in mixed infections were *Ancylostoma* spp., *Trichuris vulpis*, *Toxocara* spp., *Dipylidium caninum*, *Cystoisospora* spp., *Giardia duodenalis*, and coccidia. It was concluded that the occurrence of gastrointestinal parasites in dogs is frequent, and the variables associated with these infections were source origin, breed, age, coexistence with other animals, and dull fur.

Keywords: Helminths, preventive veterinary medicine, protozoa, zoonoses.

Resumo

O parasitismo gastrointestinal por helmintos e protozoários apresenta riscos à saúde animal e humana devido às alterações clínicas e transmissão de agentes potencialmente zoonóticos. Assim, o presente estudo teve como objetivo verificar a ocorrência de parasitoses gastrointestinais em cães do município de Cuiabá, Mato Grosso, Brasil, utilizando-se exames coproparasitológicos. De junho de 2021 a abril de 2022, foram coletadas amostras fecais de cães domésticos no Hospital Veterinário e Abrigos de Proteção Animal do município de Cuiabá. Foi aplicado um questionário semiestruturado aos tutores e responsáveis pelos abrigos para analisar os fatores associados ao parasitismo gastrointestinal. Um total de 353 amostras fecais foram coletadas e submetidas às técnicas de flotação e sedimentação parasitológica. Os dados foram analisados, utilizando-se o teste Qui-quadrado e a análise fatorial exploratória. A ocorrência de parasitismo gastrointestinal foi de 22,66%, e os parasitos encontrados

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*Corresponding author: Richard de Campos Pacheco. E-mail: richard.pacheco@ufmt.br

isoladamente ou em infecções mistas foram *Ancylostoma* spp., *Trichuris vulpis*, *Toxocara* spp., *Dipylidium caninum*, *Cystoisospora* spp., *Giardia duodenalis* e Coccidia. Conclui-se que a ocorrência de parasitoses gastrointestinais em cães é frequente, e as variáveis associadas a essas infecções foram procedência, raça, idade, convivência com outros animais e pelagem opaca.

Palavras-chave: Helmintos, medicina veterinária preventiva, protozoários, zoonoses.

Introduction

Gastrointestinal parasites are among the most common pathogens found by veterinary clinicians in companion animals and constitute one of the main causes of high morbidity in dogs (Kalkofen, 1987; Little et al., 2009). It is common in domiciled and stray dogs (Alves et al., 2005; Andrade et al., 2015; Lallo et al., 2016), and is considered a one health problem, as many of these gastrointestinal parasites can cause disease in humans (Dantas-Torres & Otranto, 2014), and contaminate the soil of daycare centers and squares (Almeida et al., 2007, 2010).

Some of the helminths that most frequently infect dogs are *Ancylostoma* spp., *Toxocara* spp., *Trichuris vulpis,* and *Dipylidium caninum*, and the most common protozoa are *Giardia duodenalis* and *Cystoisospora* spp. (Curi et al., 2017; Kostopoulou et al., 2017; Mircean et al., 2017; Saldanha-Elias et al., 2019; Snak et al., 2019; Regidor-Cerrillo et al., 2020; Lara-Reyes et al., 2021; Lima et al., 2021; Lopes et al., 2021; Lusa et al., 2021).

The occurrence of gastrointestinal parasites is variable and depends on many factors, such as age, living conditions, health status of the animal, diagnostic techniques used, and region studied (Táparo et al., 2006; Lallo et al., 2016; Mircean et al., 2017; Snak et al., 2019; Lara-Reyes et al., 2021). These diseases impair the development of the animal, and the clinical signs manifest as diarrhoea, emesis, weight loss, intestinal obstruction partial or total, anaemia, anorexia, ascites, and dull fur, which vary according to the species and number of parasites (Traversa, 2012).

Around the world, there are some reports of gastrointestinal parasitism in dogs, and the frequencies of the parasites detected were 26.5% (80/302) in Villahermosa, Mexico (Torres-Chablé et al., 2015); 40% (120/300) in Central Queensland, Australia (Gillespie & Bradbury, 2017); 26.8% (41/152) on the Lower Dir district, Pakistan (Khan et al., 2020); 63.5% (148/233) in northern Spain (Regidor-Cerrillo et al., 2020); and 11.9% (43/360) on the Shendi area, Sudan (Sulieman et al., 2020). Likewise, different occurrences are reported in Brazil, 20.5% (635/3099) in São Paulo (Ferreira et al., 2016); 43.2% (147/340) on the northeastern region (Zanetti et al., 2019); 72.55% (74/102) in Caxias do Sul (Lusa et al., 2021); and 87.5% (35/40) in Porto Velho (Lopes et al., 2021). In the midwestern region, occurrences of 48.3% (97/201) were found in Goiânia (Oliveira et al., 2009) and 85% (85/100) in Cuiabá (Ramos et al., 2015).

Due to the few studies carried out in the Midwest region of Brazil, the objective of this study was to verify the occurrence of gastrointestinal parasites in dogs from the Cuiabá municipality in the midwestern region of Brazil and to investigate the risk factors associated with parasitism.

Materials and Methods

Animals

From June 2021 to April 2022, faecal samples from dogs of both sexes, of different breeds and ages, were collected and analysed. The sample calculation followed the design described by the following formula:

$$n = \frac{N * Z^2_{(1-\alpha/2)} * \left[p' * (1-p')\right]}{(N-1) * d^2 + Z^2_{(1-\alpha/2)} * \left[p' * (1-p')\right]} = \frac{2574 * 3.84 * \left[0.5 * (1-0.5)\right]}{(2573) * 0.0025 + 3.84 * \left[0.5 * (1-0.5)\right]} = 335(minimum) \quad (1)$$

Where “N” is the population size of 2574 animals (sum of the animals attended at the veterinary hospital and the population of two shelters in Cuiabá), $Z_{(1-\alpha/2)}$ is the value of the Z statistic of the standard normal distribution for the 100(1-α)% confidence interval (CI) for the estimated proportion, “*p* ´” is the proportion of parasitised animals (which, when not known, is estimated at 0.5 (50%) as the maximum population value in order to provide the maximum sample to be treated) and “d” is the required precision, here assumed to be 0.05 (for a maximum error of 5%).

For a better understanding of the clinical history of each dog, a semi-structured questionnaire was applied to owners and those responsible for the shelters, where the dog was identified by name, breed, sex, size, and age (young: under 1 year old; adult: between 1 and 8 years old; and elderly: over 8 years old, as stipulated by Bello et al.

(2018). Information provided by the owners was used to collect data on the living conditions of each dog: whether they came from the veterinary hospital population or from shelters, if they had access to the street, if they lived in a house or apartment, if they lived with other animals, if they had a routine consultation with a veterinarian, if they controlled gastrointestinal parasites and ectoparasites, and the clinical signs presented by the dog in the last 15 days before faecal collection (diarrhoea, emesis, dull fur, abdominal distension, and presence of parasites in the faeces).

Sample collection and coproparasitological techniques

One faecal sample of each dog were collected after defaecation during clinical care, during the hospitalisation period at the veterinary hospital, or by owners at home. In the shelters, samples were collected from dogs that lived in individual pens. The dogs that lived in collective pens were released one at a time in the early hours of the morning, and the samples were collected immediately after defaecation. After collection, the samples were stored in flasks, identified with the dog's name and registration number, and sent to the Veterinary Parasitology laboratory of the Federal University of Mato Grosso for processing. The samples were stored at 8 ºC for a maximum of 24 h after collection and processed using three methods for parasitological examination: the Willis-Mollay flotation technique (Willis, 1921), zinc sulfate centrifugal flotation technique (Faust et al., 1938), and spontaneous sedimentation of Hoffman, and Pons, and Janer (Hoffman et al., 1934). After preparing for each technique, the faecal material was transferred to slides and a drop of Lugol solution (2%) was added. The samples were examined with a 10× objective and confirmation were obtained with a 40× objective under a light microscope (Olympus CX41® biological microscope).

Statistical analysis

Non-probabilistic convenience sampling was used for data collection, which were organised in a Microsoft Excel spreadsheet. The occurrence was determined by the reason of the dogs parasitised by the evaluated ones. Factors associated with gastrointestinal parasitism were analysed using the chi-square test (X^2), considering significant $p < 0.05$. Continuity corrections were not used to obtain chi-square test values. All values of the chi-square test have as invariant degrees of freedom equal to 1 (*df* = 1), except in relation to the city regions (*df* = 4). Exploratory factorial analysis (EFA) was also applied for multivariate analysis of correlations between variables, grouping them into factors, and thus identifying the most representative. The Kaiser-Meyer-Olkin test was performed to verify the applicability of EFA for the dataset. The scree plot was obtained through an EFA, using the principal components extraction and *varimax* rotation methods (maximising the variance of the factor loadings for each factor by increasing the high loads and decreasing the low loads, making it possible to identify more clearly which items correspond to each factor) (Kirch et al., 2017), in a correlation matrix composed of 16 variables. For the calculations, R software, version 4.2.0 (R Core Team, 2022) was used. Additionally, the odds ratio (OR) and CI at 95% were calculated using OpenEpi software, version 3.01 (Dean et al., 2022) to verify the risk associated with the variables that were correlated with parasitism.

Results

A total of 353 faecal samples were collected, with 304 samples from dogs at the veterinary hospital and 49 samples from dogs in shelters. The gastrointestinal parasites found alone or in mixed infections in faecal samples were *Ancylostoma* spp., *T. vulpis*, *Toxocara* spp., *D. caninum*, *Cystoisospora* spp., *G. duodenalis*, and coccidia (it was not possible to identify the genus). The absolute values and percentages of occurrence for each parasite, both in single and mixed infections, are detailed in Table 1.

Gastrointestinal parasitism occurred in 22.66% of the patients (80/353). In dogs treated at the veterinary hospital, the occurrence was 15.13% (46/304) and in dogs from shelters was 69.39% (34/49); thus, shelter dogs were approximately 12 times more likely to be parasitised when compared to dogs attending veterinary hospital ($X^2 = 67.81$, $p < 0.001$, OR = 12.57) (Table 2).

Regarding the neighbourhoods of Cuiabá, dogs from all regions of the city participated in the study. From the northern region, 36 dogs from 13 neighbourhoods, from the southern region, 62 dogs from 26 neighbourhoods, from the eastern region, 194 dogs from 38 neighbourhoods, and from the western region, 55 dogs from 21 neighbourhoods were included (Figure 1). It was not possible to determine the exact geographic location of six dogs. There were no statistically significant differences between the city regions ($X^2 = 9.13$; *df* = 4; $p = 0.058$).

Table 1. Absolute and percentage frequencies of endoparasites diagnosed in faecal samples from dogs in Cuiabá from June 2021 to April 2022.

Gastrointestinal parasites	Frequency (%)
Isolated infections	
Ancylostoma spp.	29 (8.21%)
Trichuris vulpis	9 (2.55%)
Cystoisospora spp.	9 (2.55%)
Giardia duodenalis	7 (1.98%)
Toxocara spp.	2 (0.57%)
Coccidia	2 (0.57%)
Dipylidium caninum	1 (0.28%)
Mixed infections	
Ancylostoma spp. + *T. vulpis*	10 (2.83%)
Ancylostoma spp. + *Toxocara* spp.	2 (0.57%)
Cystoisospora spp. + *D. caninum*	2 (0.57%)
Toxocara spp. + *T. vulpis*	1 (0.28%)
Ancylostoma spp. + Coccidia	1 (0.28%)
Ancylostoma spp. + *Cystoisospora* spp.	1 (0.28%)
Ancylostoma spp. + *G. duodenalis*	1 (0.28%)
Cystoisospora spp. + *Toxocara* spp.	1 (0.28%)
Ancylostoma spp., *Toxocara* spp. + *T. vulpis*	1 (0.28%)
Ancylostoma spp., *G. duodenalis* + *T. vulpis*	1 (0.28%)
Total positive samples	80 (22.66%)

There were a greater number of females than males, as well as purebred dogs in relation to mixed-breed dogs. As for breed, there was a significant difference, with mixed-breed dogs presenting four times more chances of being parasitised than purebred dogs ($X^2 = 26.1$, $p < 0.001$, OR = 4.011). Regarding age, adult dogs were more numerous, followed by elderly and young dogs; adult dogs were approximately three times more likely to be parasitised than elderly dogs ($X^2 = 11.01$, $p = 0.004$, OR = 3.419). Approximately 90% of the parasitised dogs lived with other animals, such as dogs, cats, horses, cattle, birds, turtles, and hamsters; therefore, dogs that lived with other animals were approximately three times more likely to be parasitised than those living alone ($X^2 = 6.08$, $p = 0.007$, OR = 2.749) (Table 2).

Dogs that were not administered ectoparasiticides were two times more likely to be parasitised than dogs that were ($X^2 = 6.88$, $p = 0.043$, OR = 2.16). Among the clinical signs presented by the dogs in the last 15 days before the collection of faeces, diarrhoea, weight loss, and emesis had the highest frequencies, and dull fur, abdominal distension, and observation of parasites in the faeces appeared less frequently. Only dull fur had a significant association; that is, dogs with dull fur were approximately twice more likely to be parasitised ($X^2 = 3.85$, $p = 0.024$, OR = 1.868) (Table 2). Dogs with dull fur showed parasitism by several agents, with predominance of *Ancylostoma* spp. (14/22) and a significant association was observed ($X^2 = 4.24$, $p = 0.039$, OR = 2.045, CI: 0.10 – 4.07).

In the factorial analysis, measures of sample adequacy (MSA) were made for each of the 16 variables. The variables parasites in faeces and access to the street were excluded from the factor analysis as they did not show significance. The higher the MSA value, the more suitable the variable for factor analysis. The variables presented an MSA > 0.05 (0.65), indicating good adequacy of the factor analysis data. By retaining factors using the *Kaiser-Guttman* criterion (eigenvalue > 1), two factors were retained (Kirch et al., 2017), facilitating interpretation. Table 3 describes the values of the factor loadings rotated by the *varimax* method for the two factors for each item of the semi-structured questionnaire and their commonalities. It was noted that the dogs' origin, breed, housing, and presence or absence of parasitism were positively correlated with Factor 1; therefore, this group was called demographic aspects. For Factor 2, the positively correlated items were weight loss, diarrhoea, dull fur, abdominal distension, and emesis (Figure 2); therefore, this group was referred to as clinical signs. For this factor, the variables routine consultation, endo-and ectoparasiticide treatment, sex, and age showed an inverse relationship.

Table 2. Absolute and percentage frequencies, number of dogs with gastrointestinal parasites, p (chi-square test) of each variable analysed in a semi-structured questionnaire, odds ratio, and confidence interval (CI) at 95% (with lower and upper limits) of the significant variables for dogs in Cuiabá from June 2021 to April 2022.

Variables and categories	Frequency (%)	Dogs with parasites	p	*Odds ratio* (CI Lower – Upper)
Origin			< 0.001*	12.57 (6.41 – 25.52)
Shelter	49 (13.88%)	34		
Veterinary hospital	304 (86.12%)	46		
Sex			0.054	-
Female	203 (57.51%)	38		
Male	150 (42,49%)	42		
Breed			< 0.001*	4.011 (2.35 – 7.00)
Mixed-breed	161 (45.61%)	57		
Purebred	192 (54.39%)	23		
Age			0.004*	3.419[¥] (1.61 – 8.01)
Young	48 (13.60%)	9		
Adult	219 (62.04%)	63		
Elderly	86 (24.36%)	8		
Housing			0.110	-
Apartment	45 (12.75%)	6		
House	308 (87.25%)	74		
Street access			0.997	-
Yes	161 (45.61%)	37		
No	192 (54.39%)	43		
Coexistence with other animals			0.007*	2.749 (1.3 – 6.41)
Yes	281 (79.60%)	72		
No	72 (20.40%)	8		
Routine consultation			0.208	-
Yes	196 (55.52%)	39		
No	157 (44.48%)	41		
Endoparasiticide treatment			1.000	-
Yes	327 (92.63%)	74		
No	26 (7.37%)	6		
Ectoparasiticide treatment			0.043*	2.16 (1.23 – 3.75)
No	79 (22.38%)	27		
Yes	274 (77.62%)	53		
Diarrhoea			0.435	-
Yes	126 (35.69%)	32		
No	227 (64.31%)	48		
Emesis			0.321	-
Yes	97 (27.48%)	18		
No	256 (72.52%)	62		
Weight loss			0.590	-
Yes	104 (29.46%)	26		
No	249 (70.54%)	54		
Dull fur			0.024*	1.868 (1.03 – 3.34)
Yes	68 (19.26%)	22		
No	285 (80.74%)	58		
Abdominal distension			0.542	-
Yes	35 (9.92%)	6		
No	318 (90.08%)	74		
Parasites in faeces			0.085	-
Yes	13 (3.68%)	6		
No	340 (96.32%)	74		

*p with a significant result (< 0.05). [¥]The value refers to the difference between the adult and elderly population.

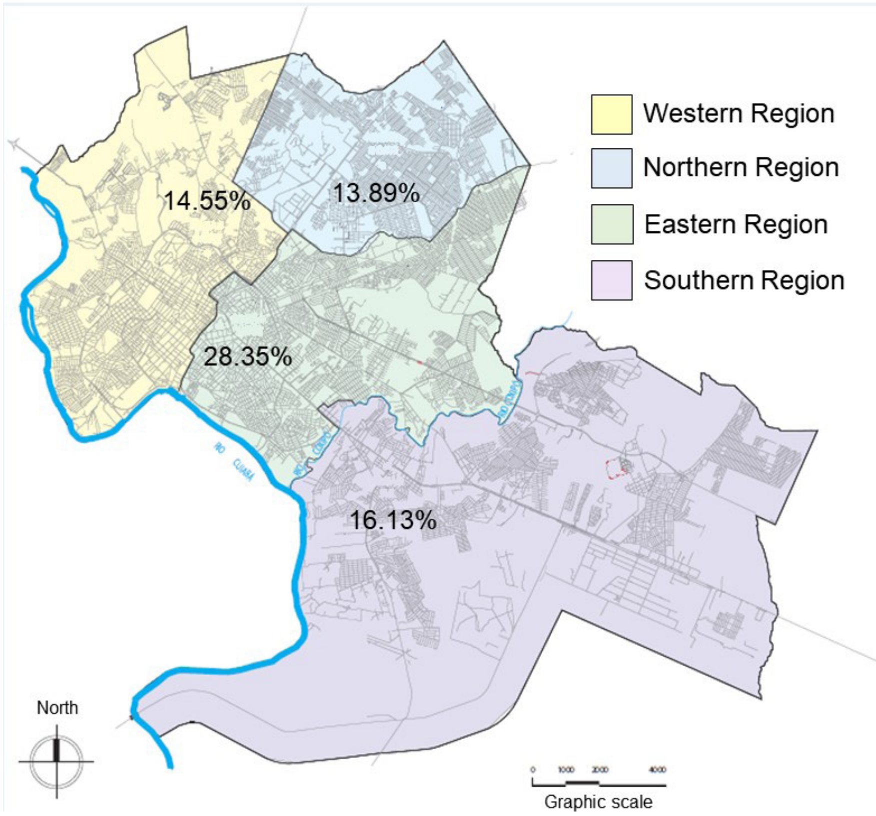

Figure 1. Spatial distribution of the occurrence of gastrointestinal parasitism in dogs by administrative regions of Cuiabá, Mato Grosso, from June 2021 to April 2022. Source: Adapted from Prefeitura de Cuiabá, Maps – Administrative Regions (Prefeitura de Cuiabá, 2007).

Table 3. Factor loadings rotated by the *varimax* method for the variables and their respective commonalities.

Variables	Demographic aspects	Clinical signs	Commonality
Origin	**0.92**	-0.12	0.86
Breed	**0.61**	0.10	0.39
Sex	-0.12	-0.34	0.13
Age	-0.02	-0.31	0.10
Housing	**0.89**	-0.12	0.80
Routine consultation	-0.15	-0.48	0.25
Endoparasiticide treatment	-0.00	-0.38	0.14
Ectoparasiticide treatment	-0.41	-0.42	0.34
Diarrhoea	-0.21	**0.58**	0.38
Emesis	-0.31	**0.44**	0.30
Weight loss	-0.13	**0.64**	0.42
Dull fur	0.16	**0.58**	0.36
Abdominal distension	-0.12	**0.45**	0.22
Presence or absence of parasitism	**0.61**	0.16	0.40

The highest observed values were highlighted in bold, representing the positively correlated variables in each factor. Negative factor loadings represent an inverse correlation between variables.

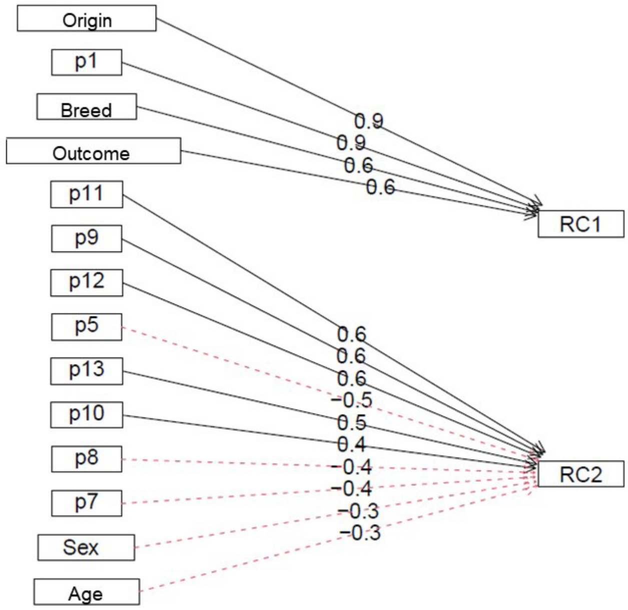

Figure 2. Factorial analysis of the complete dataset using a first-order factor model. The diagram represents the items that make up the two factors and their respective factor loadings in behavioural activities with the corresponding values. Positive correlations with the corresponding value load are represented in black. Negative correlations with the corresponding value load are represented in red. The mean of absolute values is under each factor heading. Factor one (RC1) contained four variables associated with demographic factors, namely: origin, housing (p1), breed, and outcome (presence or absence of parasitism). Factor two (RC2) contained five variables associated with the clinical signs of dogs, namely: weight loss (p11), diarrhoea (p9), dull fur (p12), abdominal distension (p13), and emesis (p10). For factor two, the inversely correlated variables were routine consultation (p5), endo (p7) and ectoparasiticide treatment (p8), sex, and age.

Discussion

In the present study, one out of every four to five dogs evaluated showed gastrointestinal parasitism by means of coproparasitological techniques, especially among dogs from shelters in the city. In the same municipality, an occurrence of 85% (85/100) of parasitism in stray dogs through parasitological necropsy was found (Ramos et al., 2015). A similar occurrence (21.65%, 94/434) was observed in domiciled and stray dogs from Goiânia, in the midwestern region of Brazil, using coproparasitological techniques (Alves et al., 2005).

The occurrence of gastrointestinal parasitism in dogs in Brazil presents values varying from 11.3% (Arruda et al., 2021) to 100% (Pereira & Barbosa, 2013). These results are owing to the different diagnostic techniques used, region studied, health status, age, and origin of these dogs (Táparo et al., 2006; Lallo et al., 2016; Snak et al., 2019).

Regarding geographic location, there was a greater participation of dogs domiciled in the eastern region of the city. This may have occurred because the veterinary hospital and the two animal protection organizations where the research was conducted are in this region (Prefeitura de Cuiabá, 2007). It was also observed that the city region did not influence the occurrence of parasitism in dogs.

Among helminths, the most frequent was *Ancylostoma* spp. (13.03%, 46/353: in isolated and mixed infections). This parasite occurred in dogs of all ages, of both sexes and of different breeds, indicating that there was no predisposition for its occurrence. Other studies also found a higher occurrence of this parasite in dogs: 12.94% (11/85) in domiciled dogs from Santos, São Paulo, Brazil (Lima et al., 2021); 76% (76/100) in stray dogs from Cuiabá, Mato Grosso, Brazil (Ramos et al., 2015); and 15.9% (48/302) in domiciled dogs from Villahermosa, Tabasco, Mexico (Torres-Chablé et al., 2015). *Ancylostoma* spp. is frequently diagnosed in canine parasitological surveys and have been reported as the most frequent nematode genus in dogs in Brazil (Alves et al., 2005; Labruna et al., 2006; Oliveira et al., 2009; Pereira & Barbosa, 2013; Andrade et al., 2015; Snak et al., 2019; Lopes et al., 2021; Lusa et al., 2021).

Trichuris vulpis was the second most frequent parasite, with an occurrence of 6.23% (22/353, in isolated and mixed infections). Other regions detected occurrences of 9.5% (9/95) in domiciled dogs from Monte Negro municipality, Rondônia, Brazil (Labruna et al., 2006); 18.3% (17/93) in stray dogs from Belo Horizonte, Minas Gerais, Brazil (Saldanha-Elias et al., 2019); and 35.2% (82/233) in stray and farm dogs from northern Spain (Regidor-Cerrillo et al., 2020). *T. vulpis* eggs can survive from cold to hot climates, especially in wet and shady areas. Unless exposed to extreme conditions for a long time, desiccation and sunlight do not often affect egg viability (Traversa, 2011). The favourable temperature range for the evolution of eggs containing the infecting larvae in the environment is from 25 to 32 °C, with higher temperatures accelerating this process (Rubin, 1954). This may explain the occurrence of this parasite in the samples collected, since the climate of Mato Grosso and consequently the Cuiabá municipality is mainly characterised by a super-humid tropical monsoon (high annual average temperature, above 24 °C, and high rainfall) and tropical climate (with summer rains and dry winters) (Governo de Mato Grosso, 2022).

Therefore, the most frequently found parasites in this study were *Ancylostoma* spp. and *Trichuris vulpis*, agreeing with a study that evaluated the contamination of squares in Cuiabá municipality (Almeida et al., 2007), and with a study that evaluated the occurrence of parasitism in stray dogs from the same municipality undergoing necropsy (Ramos et al., 2015). Despite the different techniques used for diagnosis, the result found shows that there was no change in the parasitism in dogs during the interval of 15 and seven years, respectively, between studies in the same region.

The occurrence of *Toxocara* spp. was 1.98% (7/353, in isolated and mixed infections), lower than the one reported in other regions: 3.3% (2/60) in domiciled and stray dogs from Natal, Rio Grande do Norte, Brazil (Andrade et al., 2015); 8% (16/201) in stray dogs from Goiânia, Goiás, Brazil (Oliveira et al., 2009); and 7.6% (67/879) in domiciled, sheltered and shepherd dogs from Crete, Greece (Kostopoulou et al., 2017). Infection can occur in pregnant and lactating female dogs, as well as in puppies, due to transmission via prenatal and transcolostral routes (Jacobs et al., 1977). In the population evaluated, reproductive status was not recorded, making it impossible to establish such an association. Of the dogs with toxocariasis in this study, five were adults, one was young, and one was elderly, indicating that infection can occur at any age (Villeneuve et al., 2015); and among them, five were from shelters, demonstrating the occurrence of this parasite at these places (Simonato et al., 2015; Villeneuve et al., 2015; Kostopoulou et al., 2017).

Dipylidium caninum was the only cestode found (0.85%, 3/353: in isolated and mixed infections), in agreement with studies that reported it to be the cestode species most observed in dogs (Khan et al., 2020; Rousseau et al., 2022). Different occurrences of *D. caninum* were found in other locations, such as 0.1% (3/3099) in domiciled dogs from São Paulo, São Paulo, Brazil (Ferreira et al., 2016); 13.7% (11/80) in stray dogs from Manaus, Amazonas, Brazil (Pereira & Barbosa, 2013); and 11.8% (18/152) in domiciled and stray dogs from Lower Dir district, Pakistan (Khan et al., 2020). The distribution of this cestode is directly related to the occurrence of intermediate hosts, such as fleas (Wani et al., 2015), a fact that was not recorded at the time of sample collection, and it was not possible to make such an association. In this study, two dogs did not receive ectoparasiticide treatment and one was not dewormed, that is, this factor may have contributed to the occurrence of this cestode in the population studied.

Cystoisospora spp. was the third most frequent parasite (3.68%, 13/353: in isolated and mixed infections). Higher occurrences were observed in other studies, such as: 12.5% (15/120) in domiciled dogs from western region of Paraná, Brazil (Snak et al., 2019); 6.3% (6/95) in domiciled dogs from Monte Negro municipality, Rondônia, Brazil (Labruna et al., 2006); and 14.08% (185/1314) in domiciled, sheltered, kennel, shepherd, guard, and hunting dogs from central and northwestern Romania (Transylvania) (Mircean et al., 2017). In this study, five of the 13 dogs with cystisosporosis were young, and seven of the 13 had diarrhoea, as shown by a study that correlated the occurrence of *Cystoisospora* spp. in dogs under 12 months of age (Labruna et al., 2006), suggesting that young dogs are more susceptible to infection by this parasite (Buehl et al., 2006).

Infection by *G. duodenalis* was found in nine dogs (2.55%, 9/353: in isolated and mixed infections) of all ages, both sexes, and different breeds, indicating that there was no predisposition for its occurrence. Different occurrences were reported, such as: 6.8% (10/147) in domiciled dogs from Cuiabá municipality, Mato Grosso, Brazil (Trevisan et al., 2020); 1% (1/100) in shelter dogs from Patos de Minas, Minas Gerais, Brazil (Mastrantonio et al., 2021); and 0.95% (2/210) in domiciled dogs from Hamedan province, western Iran (Gharekhani, 2014). This difference in infection rate may be associated with the coproparasitological techniques used (Mundim et al., 2003) and the pattern of intermittent elimination of cysts (Uchôa et al., 2018). The choice of the coproparasitological method and the analysis of only one faecal sample from each dog may have influenced the low occurrence of *G. duodenalis* cysts in this study. Therefore, for a better diagnosis, it would be necessary for the test to be performed on three samples collected alternately to increase the sensitivity of this test for the diagnosis of giardiasis (Uchôa et al., 2018).

Regarding the analysis of risk factors, there was no association between gastrointestinal parasitism and sex, as described in another study (Lima et al., 2021). Mixed-breed dogs (35.40%) had significantly higher gastrointestinal parasitism than purebred dogs (11.98%). This result does not necessarily demonstrate that mixed-breed dogs are more prone to gastrointestinal parasitic infections, but that this was probably related to the sanitary management that these dogs received (Snak et al., 2019); that is, they may not have been dewormed or did not undergo veterinary consultation regularly (Nunes et al., 2018). Another study also reported a greater number of parasitised mixed-breed dogs (Ribeiro et al., 2015).

There was a significant association in the age group of adult dogs; that is, adult dogs were more likely to be parasitised than elderly dogs. In addition to the adult population being more representative, parasitism by *Ancylostoma* spp. may have predisposed the difference between age groups (Ribeiro et al., 2015). In a study, an association were found between gastrointestinal parasitism and age, in which young dogs had a higher risk of infection (Lallo et al., 2016), which was not observed in the present study. Other study correlated the occurrence of *Cystoisospora* spp. and *Toxocara* spp. with dogs under 12 months of age (Labruna et al., 2006), suggesting that young dogs are more susceptible to infection with these parasites (Buehl et al., 2006). Other authors also determined that age is a risk factor for *Ancylostoma* spp. and *T. vulpis*, and that adult dogs were more likely to have these gastrointestinal parasites (Ribeiro et al., 2015).

Shelter dogs and those that lived with other animals were at higher risk of gastrointestinal parasitism, as seen in São Paulo (Lallo et al., 2016). The shelter dog population was also the one with the highest mixed infection between two and three parasites (15/49, 30.61%). The higher occurrence of gastrointestinal parasites in this study is associated with high population density (Kostopoulou et al., 2017), abandonment, nutritional deficiencies, and stress conditions to which dogs are subjected (Alves et al., 2005), which are conducive to maintaining infective forms of helminths and protozoa.

Although the use of ectoparasiticides was reported in 77.62% of dogs, non-administration of such drugs was a risk factor for gastrointestinal parasitism. These data should be analysed with caution as they may be associated with irregular sanitary management.

The factorial analysis highlighted the demographic aspects as positively correlated items, reinforcing that these factors directly contribute to gastrointestinal parasitosis in dogs. In a study, an association was found between parasitism and the origin of dogs (domiciled, sheltered or strays) (Lallo et al., 2016), similar to the results found in this study. Clinical signs were also highlighted as positively correlated items, but only dull fur had a significant association; that is, dogs that presented dull fur were more likely to present evolutionary forms of parasites to the coproparasitological examination.

The parasitism by *Ancylostoma* spp. showed a significative association with dull fur. Although this association was not observed with the other commonly reported signs of infection: enteritis, anaemia, circulatory collapse, haemorrhagic diarrhoea, growth deficit, and weight loss, which could lead to shock and death, specially of untreated puppies on nursing age (Kalkofen, 1987; Traversa, 2012).

Conclusions

The most frequent gastrointestinal parasites in dogs from Cuiabá were *Ancylostoma* spp. and *Trichuris vulpis*, and the main factors associated with parasitism were living with other animals in a shelter or residence, belonging to the adult age group, not being purebred, and having dull fur. The genera of gastrointestinal parasites with zoonotic potential found in dogs are alert to the risk of human infection, and it is important to adopt control and prevention measures in the context of one health.

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Ethics declaration

The study procedures were approved by the Ethics Committee on Animal Research of the Federal University of Mato Grosso (CEUA protocol no. 23108.003553/2020-73).

Conflict of interest

The authors declare no conflict of interests.

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